Claims

1. A method for fabricating a steel part having a target bulk composition T of iron (Fe) and N additional basic elements E_1, E_2, ... E_N, where $N \geq 1$, each present in a respective mass percentage $M_{1,T}$, $M_{2,T}$, ... $M_{N,T}$, and a melting point depressant agent E_{MPD}, present in a mass percentage $M_{MPD,T}$, comprising the steps of:

a. providing a skeleton of interconnected adhered metal particles having a network of interconnected porosities throughout, said particles packed at a packing fraction V_{PF}, said particles having a composition consisting essentially of:

i. iron and said N basic elements E_1, E_2, ... E_N, each present in a respective mass percentage $M_{1,K}$, $M_{2,K}$, ... $M_{N,K}$; and

ii. said Melting Point Depressant agent E_{MPD}, present in a mass percentage $M_{MPD,K}$;

b. providing an infiltrant having a composition consisting essentially of:

i. iron and said same N elements E_1, E_2, ... E_N, each present in a respective mass percentage $M_{1,I}$, $M_{2,I}$, ... $M_{N,I}$; and

ii. said Melting Point Depressant agent E_{MPD}, present in a mass percentage $M_{MPD,I}$, where $M_{MPD,I} > M_{MPD,T} > M_{MPD,K}$;

said infiltrant composition being complementary to said skeleton composition, relative to said bulk target composition T; and

d. infiltrating said skeleton with said infiltrant, at an infiltration temperature T_{infil}, said infiltration being driven primarily by capillary pressure, said

infiltration temperature, said infiltrant composition and said skeleton composition being such that:

i. T_{infil} is below a solidus temperature for said skeleton;

ii. T_{infil} is above a liquidus temperature for said infiltrant; and

iii. at said infiltration temperature, T_{infil}, at chemical equilibrium, a body having said target composition T, has at least about 7 vol% liquid, and is less than about 50 vol% liquid.

2. The method of claim 1, said Melting Point Depressant agent E_{MPD}, further having relatively high diffusivity in said skeleton.

3. The method of claim 1, said Melting Point Depressant agent E_{MPD}, further having relatively high solubility in said skeleton.

4. The method of claim 2, said Melting Point Depressant agent E_{MPD}, further having relatively high solubility in said skeleton.

5. The method of claim 1, said melting point depressant agent having a maximum solubility $M_{MPD-max}$ in iron (Fe), said melting point depressant mass percentage in said target composition $M_{MPD,T}$ being less than about $2*M_{MPD-max}$.

6. The method of claim 2, said melting point depressant agent having a maximum solubility $M_{MPD-max}$ in iron (Fe), said melting point depressant mass percentage in said target composition $M_{MPD,T}$ being less than about $2*M_{MPD-max}$.

7. The method of claim 1, said melting point depressant element having a maximum solubility $M_{MPD-max}$ in iron (Fe), said melting point depressant mass percentage in said target composition $M_{MPD,T}$ being less than about $M_{MPD-max}$.

8. The method of claim 1, said melting point depressant agent comprising carbon (C).

9. The method of claim 1, said melting point depressant agent comprising silicon (Si).

10. The method of claim 1, said melting point depressant agent consisting essentially of C and Si.

11. The method of claim 1, said melting point depressant agent consisting essentially of elements selected from the group consisting of C and Si.

12. The method of claim 1, further comprising the step of subjecting said infiltrated skeleton to conditions such that a portion of said melting point depressant diffuses from said infiltrated porosities into said metal powder, and at least partial diffusional solidification occurs.

13. the method of claim 12, further where at least 10% of said infiltrated infiltrant volume solidifies at said infiltration temperature T_{infil}.

14. The method of claim 1, said step of providing infiltrant comprising providing an infiltrant having a composition that is complementary to said composition of said skeleton with respect to said target bulk composition, in a mode that is between a near tie-line mode and a reverse slope mode.

15. The method of claim 1, said step of providing infiltrant comprising providing an infiltrant having a composition that is complementary to said composition of said skeleton with respect to said target bulk composition, in a mode that is between a near tie-line mode and a basic mode.

16. The method of claim 15, said step of providing infiltrant comprising providing an infiltrant having a composition that is complementary to said composition of said skeleton with respect to said target bulk composition, in an off tie-line mode.

17. The method of claim 1, said melting point depressant agent consisting essentially of carbon.

18. The method of claim 17, said target bulk composition comprising a steel selected from the group consisting of: D2, M2, 440C, Austenitic Manganese Grade C, A3, O6, 410 and T8.

19. The method of claim 1, said melting point depressant agent consisting essentially of silicon.

20. The method of claim 19, said target bulk composition comprising CN-7MS.

21. The method of claim 19, said target bulk composition comprising CF-10SMnN.

22. The method of claim 16, said target bulk composition comprising a steel selected from the group consisting of: H13, S6 And ACI-HF.

23. The method of claim 1, said steel target composition comprising D2.

24. The method of claim 1, said steel target composition comprising M2.

25. The method of claim 1, said steel target composition comprising 440C.

26. The method of claim 1, said steel target composition comprising Austenitic Manganese Grade C.

27. The method of claim 1, said steel target composition comprising A3.

28. The method of claim 1, said steel target composition comprising O6.

29. The method of claim 1, said steel target composition comprising T8.

30. The method of claim 1, further wherein:

a. said melting point depressant agent is present in said skeleton in a mass percentage $M_{MDP,K}$ between zero and the mass percentage of said melting point depressant agent in an equilibrium solid phase at a temperature where the target composition is 93 vol% solid;

b. said N basic additional elements are present in said skeleton in respective mass percentages, as follows, for n = 1 to N: $M_{n,K} = M_{n,T} + R_n * (M_{n,S} - M_{n,T})$, with $-1 \leq R_n \leq 1$ for each basic additional element;

c. said melting point depressant agent is present in said infiltrant in a mass percentage as follows: $M_{MPD,I} = M_{MPD,K} + (M_{MPD,T} - M_{MPD,K})/M_I$; and

d. said N basic additional elements are present in said infiltrant in respective mass percentages, as follows, for n = 1 to N: $M_{n,I} = M_{n,T} + R_n * (M_{n,L} - M_{n,T})$, with $-1 \leq R_n \leq 1$ for each basic additional element;

wherein said variables are used as defined in the specification hereof.

31. The method of claim 30, further wherein, for both said basic additional elements present in said skeleton and said infiltrant, $0 \leq R_n \leq 1$ for each basic additional element.

32. The method of claim 1, said melting point depressant agent having a diffusivity in said skeleton at 1100°C of greater than 2×10^{-15} cm^2/sec.

33. The method of claim 1, said melting point depressant agent having a diffusivity in said skeleton at 1100°C of greater than 4×10^{-16} cm^2/sec.

34. The method of claim 1, said skeleton comprising particles of a nominal diameter L said diffusivity D of said melting point depressant agent being such that a Metric = L^2/D is less than or equal to approximately 1.4×10^6 seconds.

35. The method of claim 1, further comprising the step of maintaining said skeleton after infiltration at said infiltration temperature for a period of time less than fifteen hours, said melting point depressant having a diffusivity such that substantial homogeneity is achieved.

36. The method of claim 1, further comprising the step of maintaining said skeleton after infiltration at said infiltration temperature for a period of time less than 3 hours, said melting point depressant having a diffusivity such that substantial homogeneity is achieved.

37. The method of claim 1, further comprising the step of maintaining said skeleton after infiltration at an austenitizing temperature for a period of time less than 3 hours, said melting point depressant having a diffusivity such that substantial homogeneity is achieved.

38. A method for fabricating a steel part having a target bulk composition T as set forth in the row entitled Target range in the immediately following table:

	C	Cr	Mn	Mo	Ni	Si	V	Fe
Target Range	1.4-1.6	11-13	0.6 max	0.7-1.0	0.3 max	0.6 max	1.1 max	balance
Infiltrant - B	3.50	17.20	0.6 max	2.0	0.3 max	0.6 max	2.30	balance
Skeleton - B	0.30	9.76	0.6 max	0.57	0.3 max	0.6 max	0.48	balance
Infiltrant - D	3.79	9.84	0.6 max	0.58	0.3 max	0.6 max	0.46	balance
Skeleton - D	0.13	12.93	0.6 max	1.18	0.3 max	0.6 max	1.22	balance

of iron (Fe) and carbon, present in a mass percentage within a range as specified in a column headed by symbol C, and additional basic elements listed, each present in a respective mass percentage within a range set forth in a column headed by said respective element symbol, said method of fabricating comprising the steps of:

a. providing a skeleton of interconnected adhered metal particles having a network of interconnected porosities throughout, said particles packed at a packing fraction V_{PF}, said particles having a composition consisting essentially of:

i. iron and said additional basic elements each present in a respective mass percentage between those as specified in a column headed by said respective element symbol in: a row entitled Skeleton-B; and a row entitled Skeleton-D; and

ii. Carbon, present in a mass percentage between zero and the mass percentage of carbon in an equilibrium solid phase at a temperature where said target composition T is 93 vol% solid;

b. providing an infiltrant having a composition consisting essentially of:

i. iron and said same additional basic elements each present in a respective mass percentage

between approximately as specified in a column headed by said respective element symbol in: a row entitled Infiltrant-B; and a row entitled Infiltrant-D; and

ii. Carbon, present in a mass percentage of at least the mass percentage of carbon in an equilibrium liquid phase, at a temperature where the target composition is 50 vol% liquid;

said infiltrant composition and said skeleton composition further being complementary relative to said target composition T; and

c. infiltrating said skeleton with said infiltrant, at said infiltration temperature T_{infil}, said infiltration being driven primarily by capillary pressure, said infiltration temperature, said infiltrant composition and said skeleton composition further being such that:

i. T_{infil} is below a solidus temperature for said skeleton;

ii. T_{infil} is above a liquidus temperature for said infiltrant; and

iii. at said infiltration temperature, T_{infil}, at chemical equilibrium, a body having said target composition T, has at least about 7% vol liquid, and is less than about 50% vol liquid.

39. The method of claim 38, further wherein:

a. said step of providing a skeleton further comprising providing a skeleton of particles having a composition consisting essentially of:

i. iron and said additional basic elements, each present in a respective mass percentage between approximately as specified in said column

headed by said respective element symbol in: a row entitled Skeleton-A of the immediately following table:

	C	Cr	Mn	Mo	Ni	Si	V	Fe
Infiltrant - A	3.50	12.00	0.6 max	1.00	0.4 max	0.6 max	1.00	balance
Skeleton - A	0.30	12.00	0.6 max	1.00	0.4 max	0.6 max	1.00	balance

and in said row entitled Skeleton-B; and

ii. Carbon, present in said mass percentage between zero and the mass percentage of carbon in an equilibrium solid phase at a temperature where said target composition T is 93 vol% solid;

b. said step of providing an infiltrant further comprising providing an infiltrant having a composition consisting essentially of:

i. iron and said same additional basic elements each present in a respective mass percentage between approximately as specified in said column headed by said respective element symbol in: said row entitled Infiltrant-A; and said row entitled Infiltrant-B; and

ii. Carbon, present in said mass percentage of at least the mass percentage of carbon in an equilibrium liquid phase, at a temperature where the target composition is 50 vol% liquid.

40. A method for fabricating a steel part having a target bulk composition T as set forth in the row entitled Target range in the immediately following table:

	C	Cr	Mn	Mo	Ni	Si	V	Fe
Target Range	0.32-0.45	4.75-5.5	0.2-0.5	1.1-1.75	0.3 max	0.8-1.0	0.8-1.0	bal
Infiltrant - B	0.88	5.73	0.33	1.80	0.3 max	2.00	1.31	bal
Skeleton - B	0.05	4.78	0.33	1.18	0.3 max	0.37	0.81	bal
Infiltrant - D	0.88	4.86	0.33	1.23	0.3 max	2.09	0.85	bal
Skeleton - D	0.05	5.34	0.33	1.54	0.3 max	0.31	1.10	bal

of iron (Fe) and Silicon, present in a mass percentage within a range as specified in a column headed by symbol Si, and Carbon, present in a mass percentage within a range as specified in a column headed by symbol C, and additional basic elements listed, each present in a respective mass percentage within a range set forth in a column headed by said respective element symbol, said method of fabricating comprising the steps of:

a. providing a skeleton of interconnected adhered metal particles having a network of interconnected porosities throughout, said particles packed at a packing fraction V_{PF}, said particles having a composition consisting essentially of:

i. iron and said additional basic elements each present in a respective mass percentage between those as specified in a column headed by said respective element symbol in: a row entitled Skeleton-B; and a row entitled Skeleton-D; and

ii. Silicon and Carbon, each present in a mass percentage between zero and the mass percentage of silicon and carbon, respectively, in an equilibrium solid phase at a temperature where said target composition T is 93 vol% solid;

b. providing an infiltrant having a composition consisting essentially of:

i. iron and said same additional basic elements each present in a respective mass percentage between approximately as specified in a column headed by said respective element symbol in: a row entitled Infiltrant-B; and a row entitled Infiltrant-D; and

ii. silicon and Carbon, each present in a mass percentage of at least the mass percentage of silicon and carbon, respectively, in an equilibrium liquid phase, at a temperature where the target composition is 50 vol% liquid;

said infiltrant composition and said skeleton composition further being complementary relative to said target composition T; and

c. infiltrating said skeleton with said infiltrant, at said infiltration temperature T_{infil}, said infiltration being driven primarily by capillary pressure, said infiltration temperature, said infiltrant composition and said skeleton composition further being such that:

i. T_{infil} is below a solidus temperature for said skeleton;

ii. T_{infil} is above a liquidus temperature for said infiltrant; and

iii. at said infiltration temperature, T_{infil}, at chemical equilibrium, a body having said target composition T, has at least about 7% vol liquid, and is less than about 50% vol liquid.

41. The method of claim 40, further wherein:

a. said step of providing a skeleton further comprising providing a skeleton of particles having a composition consisting essentially of:

i. iron and said additional basic elements, each present in a respective mass percentage between approximately as specified in said column headed by said respective element symbol in: a row entitled Skeleton-A of the immediately following table:

	C	Cr	Mn	Mo	Ni	Si	V	Fe
Infiltrant - A	0.88	5.15	0.33	1.42	0.3 max	2.00	1.00	balance
Skeleton - A	0.05	5.15	0.33	1.42	0.3 max	0.37	1.00	balance

and in said row entitled Skeleton-B; and

ii. Silicon and Carbon, each present in a mass percentage between zero and the mass percentage of silicon and carbon, respectively, in an equilibrium solid phase at a temperature where said target composition T is 93 vol% solid;

b. said step of providing an infiltrant further comprising providing an infiltrant having a composition consisting essentially of:

i. iron and said same additional basic elements each present in a respective mass percentage between approximately as specified in said column headed by said respective element symbol in: said row entitled Infiltrant-A; and said row entitled Infiltrant-B; and

ii. silicon and Carbon, each present in a mass percentage of at least the mass percentage of silicon and carbon, respectively, in an equilibrium liquid phase, at a temperature where the target composition is 50 vol% liquid.

42. A method for fabricating a steel part having a target bulk composition T as set forth in the row entitled Target range in the immediately following table:

	C	Cr	Mn	Mo	Ni	Si	Cu	Fe
Target Range	0.07 max	18.0-20.0	1.5 max	2.5-3.0	22.0-25.0	1.5 max	1.5-2.0	bal
Infiltrant - B	0.11	21.51	1.5 max	3.04	17.52	6.84	1.68	bal
Skeleton - B	0.02	17.53	1.5 max	2.58	27.00	0.75	1.79	bal
Infiltrant - D	0.05	17.75	1.5 max	2.61	26.49	6.92	1.79	bal
Skeleton - D	0.05	19.74	1.5 max	2.84	21.75	0.71	1.73	bal

of iron (Fe) and silicon, present in a mass percentage within a range as specified in a column headed by symbol Si, and additional basic elements listed, each present in a respective mass percentage within a range set forth in a column headed by said respective element symbol said method of fabricating comprising the steps of:

a. providing a skeleton of interconnected adhered metal particles having a network of interconnected porosities throughout, said particles packed at a packing fraction V_{PF}, said particles having a composition consisting essentially of:

i. iron and said additional basic elements each present in a respective mass percentage between those as specified in a column headed by said respective element symbol in: a row entitled Skeleton-B; and a row entitled Skeleton-D; and

ii. silicon, present in a mass percentage between zero and the mass percentage of silicon in an equilibrium solid phase at a temperature where said target composition T is 93 vol% solid;

b. providing an infiltrant having a composition consisting essentially of:

i. iron and said same additional basic elements each present in a respective mass percentage between approximately as specified in a column headed by said respective element symbol in: a row entitled Infiltrant-B; and a row entitled Infiltrant-D; and

ii. silicon, present in a mass percentage of at least the mass percentage of silicon in an equilibrium liquid phase, at a temperature where the target composition is 50 vol% liquid;

said infiltrant composition and said skeleton composition further being complementary relative to said target composition T; and

c. infiltrating said skeleton with said infiltrant, at said infiltration temperature T_{infil}, said infiltration being driven primarily by capillary pressure, said infiltration temperature, said infiltrant composition and said skeleton composition further being such that:

i. T_{infil} is below a solidus temperature for said skeleton;

ii. T_{infil} is above a liquidus temperature for said infiltrant; and

iii. at said infiltration temperature, T_{infil}, at chemical equilibrium, a body having said target composition T, has at least about 7% vol liquid, and is less than about 50% vol liquid.

43. The method of claim 42, further wherein:

a. said step of providing a skeleton further comprising providing a skeleton of particles having a composition consisting essentially of:

i. iron and said additional basic elements, each present in a respective mass percentage between approximately as specified in said column headed by said respective element symbol in: a row entitled Skeleton-A of the immediately following table:

	C	Cr	Mn	Mo	Ni	Si	Cu	Fe
Infiltrant - A	0.05	19.00	1.5 max	2.75	23.50	6.84	1.75	bal
Skeleton - A	0.05	19.00	1.5 max	2.75	23.50	0.75	1.75	bal

and in said row entitled Skeleton-B; and

ii. silicon, present in said mass percentage between zero and the mass percentage of silicon in an equilibrium solid phase at a temperature where said target composition T is 93 vol% solid;

b. said step of providing an infiltrant further comprising providing an infiltrant having a composition consisting essentially of:

i. iron and said same additional basic elements each present in a respective mass percentage between approximately as specified in said column headed by said respective element symbol in: said row entitled Infiltrant-A; and said row entitled Infiltrant-B; and

ii. silicon, present in said mass percentage of at least the mass percentage of silicon in an equilibrium liquid phase, at a temperature where the target composition is 50 vol% liquid.

44. A method for designing a process for fabricating a steel part by infiltrating a skeleton of metal particles, said method comprising the steps of:

a. selecting a target bulk composition T of iron (Fe) and N additional basic elements E_1, E_2, ... E_N, where $N \geq 1$, each element present in a respective mass percentage $M_{1,T}$, $M_{2,T}$, ... $M_{N,T}$, and a melting point depressant (MPD) agent E_{MPD}, present in a mass percentage $M_{MPD,T}$; [900]

b. selecting a particle type, having a representative size, and packing to a packing fraction $V_{PF}=V_K$, with a corresponding void fraction $V_V=100\%- V_K$; [902]

c. determining a temperature, T_{PF}, at which a composition T has a solid portion V_S equal in volume to V_K and a liquid portion V_L equal in volume to V_V; [904]

d. determining a tie line composition at T_{PF} for said solid portion, comprising mass percentages of each of said elements of said target composition T, said mass percentages designated $M_{1,S}$, $M_{2,S}$, ... $M_{N,S}$ respectively, and said MPD agent $M_{MPD,S}$; [906]

e. determining a tie line composition at T_{PF} for said liquid portion, comprising mass percentages of each of said elements of said target composition T, said mass percentages designated $M_{1,L}$, $M_{2,L}$, ... $M_{N,L}$ respectively, and said MPD agent $M_{MPD,L}$; [906]

f. determining a mass percentage M_S, of said solid portion and a mass percentage M_L, of said liquid portion, where $M_S+M_L=100\%$; [906]

g. determining a skeleton composition for said basic elements, comprising mass percentages of iron and each of said basic elements of said target composition

T, said mass percentages designated $M_{1,K}$, $M_{2,K}$, … $M_{N,K}$ respectively; [912]

h. determining an infiltrant composition for said basic elements, comprising mass percentages of iron and each of said basic elements of said target composition T, said mass percentages designated $M_{1,I}$, $M_{2,I}$, … $M_{N,I}$ respectively; [912]

i. selecting a temperature range T_{SAFE} ; [920]

j. determining a skeleton solidus temperature, T_{KS}, equal to $T_{PF}+T_{SAFE}$; [922]

k. determining a mass percent of said MPD agent in said skeleton, designated $M_{MPD,K}$, at T_{KS}; [924]

l. determining a mass percent of said MPD agent in said infiltrant, designated $M_{MPD,I}$, at T_{KS}, such that $M_{MPD,I}=M_{MPD,K}+(M_{MPD,T}-M_{MPD,K})/M_I$, whereby said mass percentage of said MPD element in a product formed by infiltrating said skeleton with said infiltrant is equal to said target mass percentage of said MPD element $M_{MPD,T}$; [926]

m. deciding on an amount of solidification of infiltrant during infiltration, said amount designated ΔV;

n. determining a volume of solid upon any such solidification $V_S=V_K+\Delta V$; and

o. determining a proposed infiltration temperature T_{infil} at which said target composition T has a solid volume fraction V_S; [932]

45. The method of claim 44, further comprising the steps of:

a. determining a liquidus temperature T_{IL}, for said infiltrant composition of said basic elements in mass percentages $M_{1,I}$, $M_{2,I}$, … $M_{N,I}$, and said MPD element in mass percentage $M_{MPD,I}$; [934]

b. Comparing said infiltrant liquidus temperature T_{IL} to said proposed infiltration temperature T_{infil}; and

i. if $T_{IL} < T_{infil}$, then infiltrate said skeleton, with said infiltrant composition at said proposed infiltration temperature T_{infil}; and

ii. if $T_{IL} \geq T_{infil}$, then reevaluate at least one of the parameters PF, T_{SAFE}, or ΔV and return to said step b of claim 3501, selecting a particle type.

46. The method of infiltrating of claim 3044, where said MPD agent is carbon and a second MPD agent, MPD2, and said mass percentage of MPD in said target composition T $M_{MPD,T}$ equals a mass percentage of carbon in said target composition $M_{C,T}$ and a mass percentage of MPD2 in said target composition $M_{MPD2,T}$ further comprising the steps of:

a. assigning mass percentage of said second MPD element in said skeleton, designated $M_{MPD2,K}$ which $=P_{MPD2}*M_{MPD2,S}$, with $0<P_{MPD2}<1/3$; [916]

b. determining a mass percentage of said second MPD element in said infiltrant composition so that $M_{MPD2,I}= M_{MPD2,K}+(M_{MPD2,T},- M_{MPD2,K})/M_I$, whereby a mass percentage of said second MPD element in said skeleton infiltrated with said infiltrant equals said mass percentage of said second MPD in said target. [918]

47. The method of claim 46, said MPD element comprising silicon.

48. The method of claim 44, said MPD element comprising carbon.

49. The method of claim 44, further wherein,

a. said step of determining a skeleton composition for said basic elements, comprises assigning said mass percentages designated $M_{1,K}$, $M_{2,K}$, ... $M_{N,K}$ equal to the corresponding mass percentages of said basic elements in said target composition, $M_{1,T}$, $M_{2,T}$, ... $M_{N,T}$ respectively; and

b. said step of determining an infiltrant composition for said basic elements, comprises assigning said mass percentages designated $M_{1,I}$, $M_{2,I}$, ... $M_{N,I}$ as follows:

i. $M_{1,I}=M_{1,K}$;

ii. $M_{2,I}=M_{2,K}$; and

iii. $M_{N,I}=M_{N,K}$.

50. The method of claim 44, further wherein,

a. said step of determining a skeleton composition for said basic elements, comprises assigning said mass percentages designated $M_{1,K}$, $M_{2,K}$, ... $M_{N,K}$ equal to the corresponding mass percentages of said basic elements in said tie line solid portion composition, $M_{1,S}$, $M_{2,S}$, ... $M_{N,S}$ respectively; and

b. said step of determining an infiltrant composition for said basic elements, comprises assigning said mass percentages designated $M_{1,I}$, $M_{2,I}$, ... $M_{N,I}$ as follows:

i. $M_{1,I}=M_{1,K}+(M_{1,T}-M_{1,K})/M_L$;

ii. $M_{2,I}=M_{2,K}+(M_{2,T}-M_{2,K})/M_L$; and

iii. $M_{N,I}=M_{N,K}+(M_{N,T}-M_{N,K})/M_L$.

51. The method of claim 44, further wherein,

a. said step of determining a skeleton composition, comprises, for each of said basic elements designating a respective factor R_1, R_2,… R_N, where each R_n factor $0 \leq R_n \leq 1$, and where at least one R_n factor $0 < R_n < 1$, assigning said mass percentages designated $M_{1,K}$, $M_{2,K}$, … $M_{N,K}$ as follows;

i. $M_{1,K}=M_{1,T}+R_1(M_{1,S}-M_{1,T})$;

ii. $M_{2,K}=M_{2,T}+R_2(M_{2,S}-M_{2,T})$;

iiii. $M_{N,K}=M_{N,T}+R_N(M_{N,S}-M_{N,T})$; and

b. said step of determining an infiltrant composition for said basic elements, comprises assigning said mass percentages designated $M_{1,I}$, $M_{2,I}$, … $M_{N,I}$ as follows:

i. $M_{1,I}=M_{1,K}+(M_{1,T}-M_{1,K})/M_L$;

ii. $M_{2,I}=M_{2,K}+(M_{2,T}-M_{2,K})/M_L$; and

iii. $M_{N,I}=M_{N,K}+(M_{N,T}-M_{N,K})/M_L$.

52. The method of claim 44, further wherein,

a. said step of determining a skeleton composition, comprises, for each of said basic elements designating a respective factor R_1, R_2,... R_N, where each R_n factor $-1 \leq R_n \leq 0$, and where at least one R_n factor $R_n < 0$, assigning said mass percentages designated $M_{1,K}$, $M_{2,K}$, ... $M_{N,K}$ as follows;

i. $M_{1,K}=M_{1,T}+R_1(M_{1,S}-M_{1,T})$;

ii. $M_{2,K}=M_{2,T}+R_2(M_{2,S}-M_{2,T})$;

iiii. $M_{N,K}=M_{N,T}+R_N(M_{N,S}-M_{N,T})$; and

b. said step of determining an infiltrant composition for said basic elements, comprises assigning said mass percentages designated $M_{1,I}$, $M_{2,I}$, ... $M_{N,I}$ as follows:

i. $M_{1,I}=M_{1,K}+(M_{1,T}-M_{1,K})/M_L$;

ii. $M_{2,I}=M_{2,K}+(M_{2,T}-M_{2,K})/M_L$; and

iii. $M_{N,I}=M_{N,K}+(M_{N,T}-M_{N,K})/M_L$.

53. The method of claim 44, further wherein,

a. said step of determining a skeleton composition, comprises, for each of said basic elements designating a respective factor R_1, R_2,... R_N, where each R_n factor $-1 \leq R_n \leq 1$, assigning said mass percentages designated $M_{1,K}$, $M_{2,K}$, ... $M_{N,K}$ as follows;

i. $M_{1,K}=M_{1,T}+R_1(M_{1,S}-M_{1,T})$;

ii. $M_{2,K}=M_{2,T}+R_2(M_{2,S}-M_{2,T})$;

iiii. $M_{N,K}=M_{N,T}+R_N(M_{N,S}-M_{N,T})$; and

b. said step of determining an infiltrant composition for said basic elements, comprises assigning said mass percentages designated $M_{1,I}$, $M_{2,I}$, ... $M_{N,I}$ as follows:

i. $M_{1,I}=M_{1,K}+(M_{1,T}-M_{1,K})/M_L$;

ii. $M_{2,I}=M_{2,K}+(M_{2,T}-M_{2,K})/M_L$; and

iii. $M_{N,I}=M_{N,K}+(M_{N,T}-M_{N,K})/M_L$.